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Stallard, Joshua Harrison

The problem of the sewerage...San Francisco

San Francisco

1892

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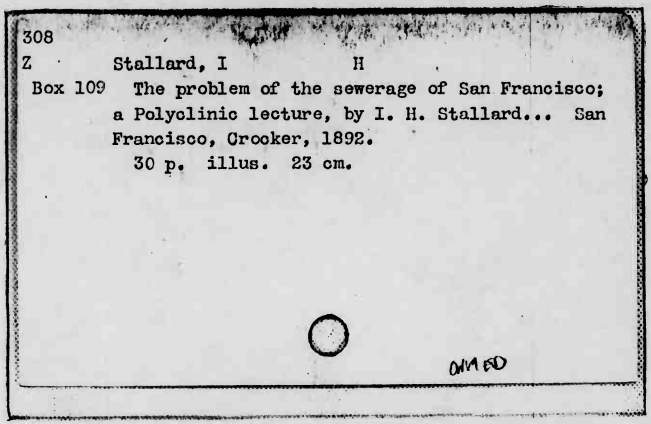
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THE PROBLEM

OF THE

Sewerage of San Francisco.

A POLYCLINIC LECTURE.

BY

I. H. STALLARD, M. B., London.

M. R. C. P., London, etc.

Physician to the San Francisco Polyclinic.

SAN FRANCISCO:
H. S. CROCKER COMPANY, PRINTERS.
1892.

LECTURE.

Mr. Mayor, Ladies and Gentlemen:

I shall offer no apology on behalf of the Polyclinic for this attempt to discuss in public the problem of the sewerage of San Francisco.

For myself, however, I crave your kind indulgence. I am not an engineer, nor shall I attempt to meddle with engineering questions. I shall speak rather as a sanitarian not altogether unfamiliar with the nature and action of defective sewers, but above all I desire to speak as a citizen of ordinary sense.

The problem before us is one of the deepest public interest. It affects the health, lives, prosperity and welfare of all classes and all ages. It is a problem which cannot be left entirely and exclusively in the hands of engineers, Supervisors, Commissioners, Boards of Works, or even Boards of Health. The citizens of San Francisco have suffered so keenly in the past from ignorant, wasteful and even injurious expenditures, to say nothing of the malfeasance of public officials and the rascality of contractors, that we may reasonably hope that no large expenditure will be incurred, even in the promotion of the public health, until the proposals and plans of operation shall have received the approval of the majority of the taxpayers; and that approval must be founded on the satisfaction of their intelligence and common sense.

I shall therefore do my best to show that the problem of the sewerage is not beyond the comprehension of an intelligent community; and it is the desire of the Polyclinic staff to assist in educating the public in all matters relating to the public health, and their hope is to create an irresistible current of public opinion in order that what is wisest and best may be speedily adopted and effectually carried out.

As a preliminary it is desirable to satisfy you that there is a problem to discuss. We have amongst us silurians who are satisfied with the existing state of things. On the authority of every annual health report they proclaim the city to be the healthiest on earth, and if we are indeed so healthy, why not be satisfied? What harm is there in a few foul sewers if we

enjoy good health in spite of them? After congratulating the citizens on their low death rate, the present officer of health calls attention to the high death rate of the Chinese, and states that the death rate of our public institutions is also exceedingly heavy. "If," says he, "we deduct the excessive death rate of our Chinese and public institutions, we should exhibit our city as one of the most healthy on the globe, notwithstanding the deplorable condition of our sewers."

Now I do not hesitate to say that the Chinese death rate is a manufactured article. The Chinese play no part in it; their number, the only basis for a calculation, is unknown. The same number of deaths which three years ago gave a death rate of 16.6 per thousand, this year gave 35.1 per thousand, and there are no special reasons for the difference.

And with regard to the deaths in public institutions there is no excess. In London the proportion is about the same. The fact is that the impecunious invalids, and for that matter the rich as well, turn their faces to the larger cities in search of the best professional advice and treatment. And assuredly there are no special attractions provided by the munificence of the dollar limit. Our so-called hospital is little better than a barn. The furniture and fittings are inferior to those of an English pauper workhouse. The patients are attended by rough and tyrannical nurses, who exercise more power than the doctors. There is no staff of dressers. The students who are there to learn the practice of their profession are mere lookers on and are not permitted either to dress a wound or bandage a broken limb. Patients are sent in for special scientific treatment, and come out disgusted, not having properly received it. The food would fail to satisfy a healthy laborer, much less the sick and delicate. Medical comforts are "*rara aves in gurgite vasto.*" The prime business of the superintendent is to keep the expenditure within the low appropriation, and the total cost of medicines, attendance and food is only thirteen cents a day for each patient. The managers are the creatures of politics. They do not appoint the staff of physicians and surgeons, and have no control over them, and the latter have no voice whatever in the management. And according to my experience, which is by no means small, the invalid must be destitute indeed who braves these horrors.

Oh! for some philanthropist who would transfer the treatment of the sick poor of San Francisco from the murky realms of politics to the glorious republic of voluntary charity, and who, like Vanderbilt in New York, would provide for the Polyclinic here a hospital worthy of the name and of our city. The staff of the Polyclinic will require no pay; and, supported by the generosity which has already accomplished so marvelous a result, we will guarantee that every patient shall receive the attendance, treatment and comforts which his case demands.

And now as to the death rate. The Registrar-General of England states that "*The rates in one country or in one city cannot be safely compared with the rates of another without correction for sex and age distribution.*" What does he mean? First as to sex. Here is the sex mortality of four large cities, and you see how different they are.

MORTALITY OF SEXES.

	Males.	Females.	Males.	Females.
Philadelphia	11,140	10,590	+ 550	
Boston	4,983	4,854	+ 129	
Baltimore	1,947	1,972		+ 25
San Francisco	4,208	2,695	+ 1,513	

The census returns for 1890 have not yet been published; but in 1880 there were in San Francisco 31,257 more males than females; and the whole of this disparity was of persons over twenty years of age. We shall presently observe the effect of this upon the death rate.

But the age distribution is still more remarkable. I present you with this table compararing the age distribution in England, Massachusetts and San Francisco:

AGES OF THE POPULATION PER CENT IN ENGLAND, MASSACHUSETTS AND SAN FRANCISCO.

	England.	Massachusetts.	San Francisco
Under 20 years	59	39	39
" 25 "	10	9	10
" 45 "	21	30	38
" 65 "	6	16	10
Over 65 "	4	6	3
	100	100	100

Here you will see that San Francisco has twenty per cent fewer persons than England under twenty years of age. Moreover, that the disparity between England and Massachusetts is the same. This difference is explained by the difference in the birth rate. In London, for example, there are annually thirty-four births (not counting still-births) to one thousand living. But in Massachusetts and America generally there are only twenty-five. We have no reliable statistics for San Francisco.

Now young infants are extremly sensitive to their sanitary surroundings. It is the most deadly year of life. About two hundred out of every one thousand die before they reach one year of age ; probably more in San Francisco. The number of deaths therefore increases with the birth rate. In London twenty-three per cent of the total mortality is under one year, but as the births are less numerous here they form only nineteen per cent of the total. If San Francisco had the same number of births to every thousand living as London, there would be at least 250 more deaths annually, augmenting the death rate nearly one per thousand.

But in the next place we have in San Francisco twenty per cent more of persons between twenty-five and forty-five years of age, and two thirds of them are males, no doubt for the most part immigrants. This period of life is subject to a low death rate. In the absence of census returns, we may estimate the number of persons living at this age in San Francisco at about 130,000; and, as we find by the last report that the mortality was 1,471, the annual death rate of this class is therefore eleven per thousand. This may appear low, but in a perfectly healthy community it would be much less.

The annual death rate of the British army in England, the men being all of these ages, is only six per one thousand, and in the sailors of the British navy it is only four per thousand. We may by this comparison safely affirm that the excessive death rate is due to preventable causes, and that, if the sanitary conditions of the citizens of San Francisco were as good as those of the British army and navy, we should annually save nearly seven hundred lives, all in the very prime of life.

There is yet another class in which, if exact data were available, we might find an unnecessary loss of life. We have

in San Francisco 86,000 children of school age,—five to seventeen,—for whom the death rate ought to be extremely low. Let me tell you how low it can be made. Some forty years ago the pauper children of London were removed to large public schools. They were taken from the lowest class ; they were of feeble constitutions, the subjects of rickets, opthalmia, scaldhead and struma. They had been badly housed, badly fed and badly clothed. They were taken from the gutters. It was thought well that the death rate was as low as fourteen in the thousand annually. But the prevalence of preventable disease led to the improvement of the drainage, and down went the death rate to eight per thousand. Soon after this the ventilation was improved, and every child given a separate bed. Then the death rate was further reduced to six per thousand. Later on more attention was paid to personal hygiene ; cleanliness was promoted, the dietary improved, and physical training introduced. Again the death rate was reduced to four per thousand, and last year such was the mproved conditition of the children, that the death rate was only three per thousand. Meantime the aspect of the children has completely changed. They are no longer recognizable as paupers. Formerly pale and weak, they have become ruddy and strong. Formerly stupid and lazy, they are now bright and intelligent. Now San Francisco may fairly boast of having the finest and brightest children on earth, and it would be a sad reflection if their death rate should be higher than that of those paupers. There are no data for comparison, but three per cent would give only 258 deaths for all the school children of San Francisco.

But sanitarians are accustomed to look less to the general rate of mortality as a test of the condition of the sewerage, than to the prevalence of certain diseases which prevail excessively when the sewerage is defective and are invariably reduced by its improvement. I have selected diphtheria and typhoid fever as typical examples, in order to compare their mortality with that of other cities. But it is desirable to observe that sanitarians believe that it is just as possible to prevent these diseases altogether as it is to prevent small-pox by vaccination. If then I compare the death rate of San Francisco with that of London or Boston, it is not for the purpose

of holding up the reputation of those cities as examples of good sewerage, for neither of them are so, but for showing how dark the sanitary picture in San Francisco is, and what great opportunities there are for its improvement.

ENGLISH AND AMERICAN DEATH RATES.—1891.

City.	Population.	Death rate.	Diptheria, per 100,000 living.	Typhoid fever, per 100,000 living.
London	4,221,452	23.3	32.0	14.0
Brighton	115,606	18.2	10.0	10.0
Norwich	101,361	19.3	27.0	20.0
Liverpool	517,116	27.0	12.0	25.0
Hull	200,934	21.0	7.0	22.0
Boston	448,477	22.5	100.0	32.0
Cincinnati	325,000	19.8	124.0	63.0
Philadelphia	1,046,964	20.7	50.0	54.0
San Francisco	330,000	20.0	100.0	40.0
Alameda	12,000	12.0	.75	.0
San Diego	16,000	11.3	.00	.75

Diphtheria is not as closely associated with defective sewers as typhoid fever. It is propagated largely by personal intercourse. But its germ is extremely persistent. It lies dormant for a long time in dirty linen, dirty walls and floors, filthy subsoil, and in sewer filth. The germ is propagated on the surface of filth and the damp walls of sewers. In San Francisco last year there were 318 deaths, whilst in all London there were but 568. In London the rate is thirty-two per 100,000 living, and in San Francisco one hundred per 100,000 living, or more than three times as many in proportion. In many parts of London there was absolutely no diphtheria. If the mortality in San Francisco had been at the London rate, there would have been ninety-six deaths, and we should have saved 222 lives. For every death there were at least five recoveries, so that we have had over 1,200 cases. At only $100 each for nursing, doctors and undertakers, we have lost $120,000 last year by the excessive prevalence of this one disease.

No fact in sanitary science is better established than the close connection between defective sewers and typhoid fever. Mainly by sewerage improvement the English death rate from typhoid fever has been reduced since 1869 from thirty-nine to seventeen in 100,000. Last year we had 129 deaths, or forty in 100,000 living. In London last autumn the whole medical

press was down on the sanitary authorities, owing to the prevalence of typhoid, and yet last year there were only fourteen deaths in the 100,000 living. If the mortality in San Francisco had been at this rate, there would have been forty-two deaths in 1891, so that there was an excess of eighty-seven deaths. For every death about twenty persons suffer, making, therefore, 1,740 illnesses. The average duration of each illness is at least one month, with a convalescence often prolonged for several more. If we make the modest estimate of $200 for the cost of nursing, feeding, doctoring, burying those who die, the loss of wages during sickness, and the impaired constitutions of those who recover, we have in one year, from one disease only, a total loss of about $350,000.

Time will not permit me to prove the deadly influence of defective sewerage on other diseases, such as la grippe, pneumonia and consumption. By lowering the standard of vitality, bad air makes the whole community more susceptible to attacks of disease, and destroys our power to resist them. But I cannot forbear from quoting the experience of my native town. For a series of years before the execution of any sanitary works, Leicester had an annual mortality from Phthisis of 435 per hundred thousand living. Thirty miles of sewerage were constructed, and the rate fell to 252. During the last twenty years the sewers have been greatly extended, and the outfalls improved. The Phthisis mortality is now 170 in 100,000. In San Francisco we had reported 959 deaths, or about 300 in 100,000 living. By using the same means we may expect the same result, which would effect a saving of 450 lives.

I trust I have demonstrated beyond a doubt that we have, in San Francisco, a wide field for sanitary improvement. No city in the world is built upon a healthier site or enjoys a healthier climate. The inhabitants have been drawn from every quarter of the globe. They are distinguished for their physical and intellectual development. They inhabit well-built houses, have an abundant and good supply of water, and they are justly entitled to expect the longest lives. There are large country districts and some towns of considerable size, both in the East and England, which have an annual death rate of only twelve per thousand. This is the standard proposed by the late Sir Edwin Chadwick for all large cities,

and this is the standard we should aim to reach. The deaths would then be about four thousand in the year as against 6,650. Suppose, however, we attain to the salvation of two thousand lives. We may reckon the cost of funerals at one hundred dollars each, and save two hundred thousand dollars, Add to this five unnecessary illnesses for every death, and put down the cost of nursing, doctoring, loss of wages and impaired constitutions, at $150 each, and we have altogether a million and a half to be saved within one year. For the sake of argument, give me this sum and I will try to point out in what direction it may be spent with the best advantage.

In discussing the problem we have in hand, I shall quote largely from the report made by Mr. W. P. Humphreys in 1876, to the Board of Supervisors.

After visiting European and Eastern cities, Mr. Humphreys presented his plan of sewerage, which was fully indorsed by Col. Alexander, of the U. S. Army Engineers. Although not formally adopted, this report has exercised much influence over the construction of sewers by his pupils and successors in office, and many of his recommendations have been commenced and some of them more or less completely carried out.

I shall also refer to the report of Mr. Harrison Smith, presented four years ago, in which the scientific principles involved are discussed and the various areas of drainage are defined. This report was indorsed by Prof. Le Conte.

I shall also have to quote the opinions of my friend Sir R. Rawlinson, K. C. B., who was for so many years the sanitary advising engineer for the Governments of England and India, and without whose approval no extensive works of sewerage could be carried out in those countries.

"The true purpose of a sewer," says Mr. Humphreys, "is " the ready removal of rainwater and all organic refuse capa- " ble of being conveyed by water from the vicinity of dwell- " ings to the bay. The day's sewage of each street and house " should be removed from the city on the day of its produc- " tion before decomposition begins. All sewers should be of " proper size and grade in order to be made self-cleansing."

The rainfall is his first consideration, and quoting from Mr. Tennant he finds that the heaviest rain recorded occurred on the 19th of December, 1886, and amounted to 4.28 inches in

the twenty-four hours. Arbitrarily adding thirty-nine per cent to this he concludes that no rainfall is likely to exceed one-fourth of an inch per hour. He then proceeds to guess at the quantity which will reach the sewers in a given time,—one hour; and again with no more evidence he fixes it at sixty per cent. Fifteen hundredths of an inch of rainfall within an hour had to be provided for by sewers. This, for an acre, his unit of area, would be 544.5 cubic feet.

The daily flow of household sewage per head of population is next considered. On this point there was at that time no established evidence. It was all guess, and he places it at sixty gallons per head, and says it is a large allowance. To reduce this to his unit of an acre he makes another guess, that there are eighty people living on that acre. This gives 640 cubic feet per acre, half of which he believes will reach the sewers in eight hours, or at the rate of forty cubic feet per hour,—making a total for rainfall and sewage of 584 cubic feet her hour.

Lastly, as it is certain that many localities have more than eighty persons on the acre, another arbitrary guess is made, and the total is raised to 617.10 cubic feet per acre per hour, or 10.285 cubic feet per minute. This scale of capacity was calculated to solve the problem, and there is no doubt it was practically adopted in the construction of the sewers from that date.

Now the 617.10 cubic feet equals 4,628 gallons which for the total area of the city is about fifty million gallons in an hour; and we need no longer wonder that sewers have been erected eleven feet six inches wide, or only six inches less than the great outfall sewers of London, which are only twelve feet wide, and which carry the sewage of 4,220,000 people, and through which are transmitted one hundred million gallons in a day.

Mr. Smith is much more cautious. He says there are no reliable data for the calculation of an hour's rain, and that the largest rainfall of a day might be passed safely through a sewer of moderate size if equally distributed over many hours. He says that large sewers are extremely objectionable as conduits for ordinary sewage. He observes that the quantity of rainfall which will reach the sewers in a given time depends upon the character of the surface, whether paved or otherwise,

whether open or covered with houses, the inclination and geological formation of the ground, all of which vary greatly sometimes in contiguous blocks.

Sir R. Rawlinson says that no calculations can be relied on to determine rainfall, and that the primary office of a sewer is to carry sewage, that is, the effete organic refuse of associated human life. That it is the first duty of the engineer to *preserve intact* and *to improve* the natural watercourses, and *to add to them if practicable*, so that as much rainfall as possible may be passed to the natural outlets through the natural channels, or in other words, kept out of the sewers. This he calls the separate system. He states that in India, where the seasons are wet and dry, like those here, but more pronounced, the heavier the rainfall the smaller must the sewers be.

This advice seems to be right and good. Its object is to preserve the purity of the natural streams and watercourses; to reduce the dimensions and increase the definition of the problem to be solved; to restrict the amount of sewage which even when highly diluted is a filthy liquid; to keep the size and cost of sewers within moderate proportions, and lastly to restrict the admission of sand, which is both difficult and costly to remove, which checks the velocity of the sewage current, and favors the formation of deposits giving off dangerous emanations.

Now let us examine an example of Mr. Humphreys' plan, and place it in contrast with the advice of Sir R. Rawlinson.

In the southwestern part of the city there was formerly an open watercourse called Precita creek; it ran in a somewhat tortuous course from Mission street down what is now called Army street near Twenty-fifth, to the San Bruno road, and was lost on Mission Flats near to the pest-house. This creek, like all others in California, was dry in summer and occasionally ran full in winter. Its depth was considerable, and it was about a mile long. Soon houses and streets were built upon the banks, and the sewage of those houses was discharged into the open watercourse. In a few years this grew to be an intolerable and dangerous nuisance, and is not cured to-day. About 1875 an Act of the Legislature was obtained to abate the evil at the cost of the whole community.

Now, according to the proposals of Sir R. Rawlinson, the creek should have been restored to its natural office, viz., the

transmission of the rainfall to the bay. Sewage should have been kept out of it by intercepting sewers, which should have been put upon its banks. These, by no possibility, need be large, as the sewage here is not the one-thousandth part of a storm rainfall, and their cost would have been a bagatelle.

Instead of doing this, the engineers of San Francisco proceeded to put the whole mile of creek into the sewer. They constructed a sewer which is eleven feet and six inches wide, eight feet and nine inches from top to botton, and has an invert only fifteen inches deep, that is, nearly flat. Through this sewer you might drive a wagon. The first cost to the city was $160,000, and more than $40,000 have since been spent upon its extensions. The outlet is 930 feet in length and is made of wood. It is tortuous in its course, and affords a brilliant example of the San Francisco engineering. It is only six feet wide, with a contracted bottom, and four feet, six inches high, consequently its area is about one-fourth that of the sewer from which it commences and which it is expected to keep empty. It has a fall of fifteen inches in the distance. This seems indubitable proof that the original sewer was at least four times too large.

And now let us examine the result. As a creek it is undoubtedly a costly success. The filth, if there is any, is out of sight. It carries off the rainfall. It rarely runs more than one foot and a half in depth, and then only for a few hours in the year. In the rainy season the sewerage proper cannot be recognized as such. The current is increased by numerous land springs from the hills above Noe and from Bernal Heights. Immense quantities of sand and gravel are brought down. The scour has washed out the cement between the bricks, and the floor of the sewer is like a cobble-stone pavement, providing a lodgement for filth as soon as the scour is over. Meantime the fine sand is washed into Mission creek and the coarse gravel left behind. Every year it has to be removed by hand labor. Last year it took five gangs of men six weeks to take it out, and the cost must have been more than two thousand dollars. This gravel is eagerly sought after by the people living near to make garden walks, and it has been used to pave the streets.

But now what happens when the rain has ceased and the springs are dry? There is now nothing remaining but domestic sewage, every gallon of which is supplied to the district by the Spring Valley Water Works.

The flow of sewage according to my own observation rarely runs more than three or four inches deep. For an hour a day it might possibly be six; but it is intermittent, ceasing altogether for some hours when its producers are asleep. The current first brings down the sand which was washed into the sewers in the higher levels. The invert is reduced in depth and becomes flat at the bottom. The velocity of the current is reduced. Soon are brought down, step by step, all those articles of domestic use which ignorant housekeepers, lazy domesties and mischievous children are accustomed to cram down their water-closets, viz., rags, bones, dish-cloths, old shoes, worn-out articles of clothing, broken glass, earthernware, spoons, knives and forks and children's toys of every kind; and these, in this wide and sluggish stream, become stranded on the sides and bottom of the sewer. Deltas of filth collect at the entrances of the laternal sewers. Thus a deposit of filth is soon formed: stench and dangerous gases are given off, which, passing up into the drainage area, infect the whole district with their dangerous effusions. One effect, however, is to purify the sewage in a small degree, so that when it reaches a lower part of the sewer we find a different condition of affairs. The sewage flow no longer occupies the middle of the sewer, but is diverted by the accumulation of islands of deposits. The stream becomes winding and divided into a hundred channels, each a few inches wide and deep, or meanders from side to side like creeks on the muddy fore-shores of the bay. Thus we have formed a sort of subterranean sewage irrigation farm; plants of a low order of vegetation grow in the dark and murky atmosphere, and when the sewage arrives at the outlet near Islais creek its character has entirely changed. It has become bright and sparkling; it has lost all its odor; in the graphic words of the gentlemen who has his tannery at the outlet,—"In the early days," said he, "I have drank much worse looking water, and if I did not know where it came from I would not hesitate to drink this now. Sure it is soft and admirably adapted to manufacturing and laundry purposes."

So, ladies and gentlemen, we have here constructed at enormous cost a huge sewer for the purpose of removing the day's sewage from each street and house to the bay, *on the day of its production, before decomposition can take place*, which fails completely to perform its duty, and, at the very time of year when the organic refuse becomes most dangerous and deadly, absolutely retains the whole of it for months together to destroy the health and lives of those who live above it, and for whose benefit it was ostensibly coustructed.

But I must further illustrate by another case.

The Channel-street sewer was built in 1872; and in 1876 Mr. Humphreys stated that the completion of the drainage of Mission creek was a most urgent matter. The sewer was designed to drain an area east of Twenty-second street, reaching to Douglass and the Park. This area will shortly be increased at least one-third by the addition of the Fell-street system. The Fell-street sewers are 10,300 feet long, and the contract is not yet completed. The cost to the property owners is $125,000. The whole of the drainage of this district will pass through the Channel-street sewer, which goes from Eighteenth street near to Potrero avenue to Ninth and Brannan streets. This part of the sewer is 4,000 feet long, and for the greater part of its course it is nine feet six inches wide, and seven feet six inches high, with an invert like that of Army street. This sewer cost $176,000, and its extension along Eighteenth street $25,000 more; and now let us examine its workings. It goes without saying that it brings down a large amount of sewage, which, however, has become thoroughly stinking and putrescent long before it arrives at the outlet. The Eighteenth-street sewer, a five-foot oval, from which the Channel street begins, now contains three feet two inches of deposit, leaving only a small segment open at the top of the sewer for the flow of sewage. Nearly all the lateral sewers are more or less obstructed. From the day of its construction the Channel-street sewer has been more or less choked by sand brought down from the immense drainage area. The sand is black and stinking. Yearly attempts have been made to clean it out. Two or three years ago a zealous Superintendent of Streets put twenty-five men to work upon it, but their efforts were in vain. When they made a hole in the sand one day, they found it

filled up the next. After two weeks' work the attempt was abandoned. In September last the deposit reached to the depth of four feet nine inches, occupying considerably more than half the capacity of the sewer. It contained about 18,000 cubic yards of filth, and a contract was let for $4,000 to have it cleaned out. Work was commenced on the twenty-fifth of last September and the men are still there. At first five men were employed; then for two weeks, twenty-five; then the contractor sold his contract in despair to Mr. Tilton, senior. By an ingenious flushing arrangement, about half of the deposit is now removed. At my last visit two or three days ago it was still two feet three inches deep. The contractor finds that the sand comes in almost as fast as he can take it out. If work is discontinued on the Sunday, he finds on Monday morning two inches more of sand than there was on Saturday. I had him measure the increase from one night's rainfall, and it was four inches. Sand enough has been taken from this sewer to fill it three times over. I doubt seriously if the contract can ever be fulfilled, and the contractor states that it will require the constant attention of at least two men to keep it reasonably clear. The condition of this sewer indicates another difficulty, viz., the impossibility of erecting large brick sewers in a soft, sandy soil permeated by water, or below the tidal line. The contract provided that in soft ground the sewer should be adequately supported by timber and concrete; but in spite of this the sewer has gradually sunk at both ends and is now broken in the middle. I am informed that it would cost $25,000 to repair the damage. All these evils would have been prevented, the greater part of this ruinous expenditure would have been saved, if the rainfall had been conducted directly and in unpolluted channels to the Mission creek, which it would have kept in a clean and wholesome state; and the sewage, instead of being a source of constant and interminable pollution, might have been otherwise disposed of. This sewer was the work of Mr. W. P. Humphreys, and if these are specimen self-cleaning sewers, to be built upon the data to be supplied by this gentleman to the new Board of Engineers at the cost not exceeding $600 a month, it is time to appeal to the common sense of the community to prevent any such accomplishment.

One more example before I pass on. The Brannan-street sewer was devised by Mr. Humphreys to carry the sewage of

Channel street to the bay. It was commenced at First street and was completed as far as Fourth street in 1881–82. It is of the same size and shape as Army street. $68,000 was the cost. It is level from end to end. The mouth of the sewer is wholly submerged at high tide. This sewer is now in course of extension to Ninth street, where it will connect with Channel, and here also it is practically level. The tide, therefore, will nearly fill the whole sewer up to Ninth street. The overflow will thus be permanently obstructed. The contract, now in course of fulfillment, is $68,000, and it may be more, owing to the difficulties encountered in constructing such sewers in soft sand below the tide level. As it is obvious that the outlet will become a frightful nuisance in the neighborhood of the Pacific Mail dock, I observe that a proposal has been passed to erect a wooden outlet, seventy-five feet in length, to carry the sewage outflow into the deeper water. I believe it is also proposed to place a huge valve upon the outlet which is to open only when the tide is low. What will be the probable result? Such an arrangement is not likely to promote the outflow of sewage or the cleaning of the sewer; and the sewage which does get out, being lighter and warmer than the sea water, will rise immediately to the surface as a black, stinking liquid, and will float around and foul the foreshores near. Here then, when completed, we shall have one of the longest tidal sewers in the world. Millions of gallons of salt water will flow in and out with every tide, and the gases generated will be driven back upon the upper reaches of the city, where they will create disease. "All tidal outlets," says Sir R. Rawlinson, "must be absolutely disconnected from the house sewers." It is lamentable to think that such immense sums have been wasted upon the construction of such dangerous works.

Hitherto I have confined my attention to the more recently constructed works, and have described only the salient points; but time and words both fail me in the attempt to describe the condition of the down-town sewers. These were constructed between 1858 and 1874, are 74 miles in length, at a cost of $36,000 per mile. In those days all sewers were made large enough to allow the admission of a man to clear away deposits. Alleys and short streets, where there are only a few houses,

have sewers of the same size as those of the largest streets. The grades are most irregular, and as they approach the bay the sewers are either level or run up hill. All the sewers below Montgomery street are tidal. The outflow being checked, they become elongated cess pools badly choked with filth. In 1885 an inquiry was made as to the condition of sewers in this respect, and it was estimated that there were 18,000 cubic yards of filth in those examined. I have lately visited many of these sewers under the guidance of the officer of the Street Department, who made the previous examination, and I am satisfied that there is no material improvement. Here and there their condition may be better but oftener it is much worse.

These sewers illustrate every possible defect. Their size and shape are not uniform. Sometimes there is 16-inch pipe made to take the sewage of a five-foot sewer. On Fifth street at Bryant the bottom of the lateral is eighteen inches below that into which it must discharge. In many there are rotten bricks, sandy mortar, and in one place the bricks were found replaced by empty barrels. It is difficult to make a large brick sewer water tight; and when a rainstorm comes the sewage pours out with the subsoil, poisoning the very foundations of the city. The foul subsoil air is kept down by modern improvements, and is forced out sideways under the basements of the houses. The expense of cleaning and repairing sewers would soon suffice to reconstruct the entire sewage of San Francisco. One year it amounted to $34,775 The McAllister-street sewer is one of the best in the city It runs from Devisadero to Market, and its grade is uniform and favorable. It carries a large bulk of sewage. From the 1st of January, 1891, till now, it has cost $846.29 for cleaning and repairs.

Whether full or empty, the larger the sewers the greater is the stench. The stinks of Chinatown rise uninterruptedly to the palaces of Nob Hill. I remember returning from a night's visit on a lovely summer morning at sunrise, and I was nearly suffocated with the stench near Mr. Haggin's house.

I have thus demonstrated that there does not exist one single yard of sewer in this city which fulfills the problem as proposed,—not a yard which fulfills its duty with safety to the public health. In fact the more sewers we make on the principles laid down by engineers, the more is the public health impaired.

THE EFFECT OF MORE SEWERS.

Year.	Total Length of Sewers, Miles.	Death Rate.	Zymotic Diseases, per 100,000.	Diphtheria, per 100,000.	Typhoid Fever, per 100,000.
1880–81 . .	130	18.5	275	16.6	37.1
1885–86 . .	153	19.0	277	79.8	36.0
1890–91 . .	227	20.15	316	100.0	43.0

But it is time to restate the problem we are discussing in accordance with our knowledge of sanitary science and the laws which regulate the propagation of disease. Here, then, is my sanitary standard. I maintain that "all the organic "refuse of associated human life, which can be conveyed by "water, must be promptly and completely removed miles "away from the dwellings of the people in *well-flushed and* "*well-ventilated* conduits, in such a manner as to prevent the "growth and propagation of putrefactive and disease-pro-"ducing germs, and to no other destination than the land "which thirsts for it, the land which alone disarms it of its "dangers, the land which becomes exhausted and unfertile if "its demands for organic refuse are not naturally supplied."

No fact is better established than the intimate relation between putrefaction and disease, and putrefaction cannot occur even in organic refuse if the germs have been destroyed. Typhoid fever, diphtheria, measles, scarlet fever, erysipelas, childbed fever, whooping cough, diarrhea, dysentery, cholera, pneumonia and consumption are all germ diseases. It has been shown that many of these germs are associated with sewer emanations, and that others grow rather in the subsoil or on the surface of dirty linen, dirty walls or the surface of manure heaps. All fluids containing organic refuse contain germs in more or less abundance. Sometimes there are one thousand and another time as many as 50,000 in a single drop. Sometimes they are innumerable.

The number of germs of sewage is multiplied during its course through the sewers. It is in the drains and sewers that the germs find all the conditions favorable to germ life, viz., warmth, moisture and organic refuse. I have a letter

from Dr. Sternberg, America's most distinguished bacteriologist, stating that all the more dangerous microbes grow best in dark and ill-ventilated places; that the damp walls of sewers are excellent cultivation surfaces. I remarked but now that the sewage of Channel street gave certain proof that putrefaction had commenced long before the sewage reached the outlet. There are over 50,000 germs in one single drop of this sewage, and every germ in that drop, if placed in a culture medium, gives rise to a colony of millions. The larger the sewer in proportion to the quantity of sewage passing through it, the greater is the growth of microbe life.

When sewage travels onward through clean conduits, it carries with it the few germs which it may at first contain or afterwards acquire on the road, but stagnation, even of only a teaspoonful for a few short hours, allows of the development of a million germs. The germs thus grown mix with the moisture of the sewer air, and if not at once destroyed, as they will be by contact with pure air, they are diffused over the whole interior of the sewer and are liable to escape into the subsoil and the houses. The absence of foul deposits is, therefore, no test of that cleanliness which is necessary for public safety. Let us take for example, say a sewer on the side of Clay-street hill. The sewer is three by five feet and you may walk up it. Grant that it has been well graded and is in good repair, almost an impossibility on a rapid grade where the velocity of the storm-waters wash out the bricks from the bottom and leave it broken into holes.

Our sewer, however, shall be smooth and dry. From time to time a momentary flow of sewage comes from some neighboring house. It passes down to the bottom with great rapidity, but enough is left behind to saturate the brickwork. The whole interior soon becomes, therefore, damp with filthy vapor in which the putrefying and disease-producing germs grow with extraordinary vigor. There may be a deposit in a nearly level sewer, but if the sewage flow is steady and occupies the greater part of the sewer's area there is no space for the germs to grow upon the walls. The oftener a sewer is nearly filled with flowing sewage the safer it will be.

No sewers are so dangerous as those which are nearly always empty and in which no deposits can possibly occur.

These are the self-cleansing sewers of the engineers. Germs are universally present in the atmosphere, and they seize upon organic refuse immediately. Filth, therefore, cannot be removed by filth. What would any of you ladies say if you should see the cook cleaning her kitchen floor with dishwater, or worse still, with house sewage in the aggregate. It must therefore be assumed that no sewer can be self-cleansing from a sanitary point of view. The only means to prevent the growth of putrefaction and disease-producing germs is to flush all sewers repeatedly and effectually with that best and cheapest germicide, clean cold water, and to ventilate them thoroughly with pure fresh air. In order to protect and maintain the public health, I maintain that every sewer in the city should be flushed so as to run three-fourths full, and with a velocity of not less than three feet per second, every six hours regularly, both by day and night. In the next place, it is obvious that sewers, to be thus treated, must be restricted in their size. A mountain torrent would scarcely suffice to flush out the great sewers to which attention has been drawn. It is also impracticable to flush a five-foot sewer. Nearly every autumn the sewer authorities have a flushing craze. You see men at the corners turning in water from the nearest hydrant through a four-inch hose. You hear considerable commotion at the point of entrance, a little foul material is moved on a few feet by the initial current but this is soon retarded into a trickling stream which passes on whilst the solid filth is left behind. The cesspool is cleaned, but its contents are washed into the sewer.

Thus then we are driven, first by the sad experience of the past, and now by purely scientific reasoning, to small sewers and the exclusion of the rainfall. Now I would observe that the question before us requires no engineering data for its settlement. We are told by the University Professor of Civil Engineering, Prof. Soulé, that Col. Waring, the most distinguished advocate of the separate system, has no reputation amongst engineers and owes his notoriety to the newspapers. But years before Memphis was sewered on the separate plan, the principle was maintained by Sir Edwin Chadwick, and has been, to a large extent, acknowledged by Sir R. Rawlinson. Besides, the newspapers are not always wrong. The fact is

that small sewers are altogether outside the experience of the majority of engineers accustomed to the construction of sewers large enough to carry off the rainfall, and who are satisfied with the so-called self-cleansing process. The small sewer appeals to the intelligence and pockets of the people rather than to interests of experts who live on high contracts and fat commissions.

But again. Once it is settled to exclude the rainfall, the problem is simplified, and we stand on firmer ground. We are no longer embarrassed by the prospect of excessive rainfalls which will burst the sewers and flood the cellars, nor will the seasons interfere. The quantity of house sewage is a bagatelle compared with rainfall. It is uniform throughout the year, and may be estimated with reasonable exactitude. In this city it consists wholly of the domestic water supply furnished by the Spring Valley company, whose meters may be made available for its measurement. Our sewerage authorities have no conception whatever how small it really is. Mr. Humphreys estimates the quantity at eight cubic feet per day per head, or about sixty gallons. Mr. Smith put it down to twenty gallons, and states that there is little doubt that, if the rainfall could be excluded from properly constructed sewers, they would become self-cleaning. As this estimate is still too large, it must be affirmed that the utmost that can be expected from household sewage is to carry the more solid matters to the street, and that all public sewers must be flushed to keep them clean.

In England inquiries have recently been made on this very question, and it is stated on the best authority that the quantity of water required for household consumption, giving a fair allowance for general purposes, and including water-closets and baths, is more than covered by an average of ten gallons per head per day. This is more than confirmed by inquiries I have made here. Failing to obtain the necessary information at Spring Valley, I applied to the health officer at San Diego, who, after careful inquiry, states his astonishment that the domestic consumption there is only eight and one-half gallons per head per day. I have also ascertained, through the kindness of Mr. Mastick, the domestic consumption in Alameda during the month of January last. The average monthly consumption per house was 2,759 gallons, or eighty-nine gallons per day. In Alameda there are seven persons to a house. The total domestic consumption is less than thirteen gallons per head per day. Ten gallons per head in San Francisco is three million gallons daily, and as a sewer twenty-four inches in diameter with a gradient of one to one thousand will deliver four million gallons in twenty-four hours, it follows that the whole daily domestic sewage of our city might be discharged through a twenty-four inch sewer in eighteen hours. It is therefore evident that, rainfall being excluded, we have no need for large sewers. The problem is indeed reduced to reasonable and exact dimensions, and our health and pockets will be saved. This conclusion has been abundantly confirmed whenever small sewers properly constructed and properly administered have been tried. In Berlin there are no sewers larger than twenty-four inches in diameter, and the house drains are only four inches. When one drain does not suffice to carry off the sewage, as may be the case in large hotels, the sewer is not enlarged, but a second of the same size is put in. The system of small sewers has now been adopted in many American cities, and the number is increasing daily. Under the advice of Col. Waring it has been constructed at San Diego, Los Angeles, Santa Barbara, San Luis Obispo and Stockton, in the last case under the immediate direction and advice of Mr. Marsden Manson. It is also in operation at the Leland Stanford Junior University. As experience shows the difficulties encountered, improvements have been made.

I will now give a few examples: First, San Diego, which occupies an area of one thousand acres and has sixteen thousand inhabitants. There are forty-one miles of sewers, of which thirty-five are in daily use. The main sewer is twenty-four inches in diameter. There are sixty-five flushing tanks in daily use, and eleven are operated on alternate days. One man is required to keep them in order. The water bill for flushing is forty-three dollars a month. During the greatest flow the sewers run one-third full. Even in business streets full of houses the sewers do their work well. The streets are swept daily after business hours, and there is no trouble with the rainfall. Where there are elevators a four-inch drain

was found inadequate, and a six-inch had to be put in. The total cost was $386,000, including a long outfall sewer and a costly sewage reservoir, which proved a great mistake and is now disused. In 1891 the death rate was 11.3 per thousand, and this in spite of the deaths of many invalids attracted by the climate. There has been no diphtheria, no diarrhœa, and only one death from typhoid fever. Dr. Magee writes that there are no deposits, no stoppages, no smells, that the sewers work well and are a great success.

The second example is nearer home. In Alameda the sewerage has been recently reconstructed under the direction of Mr. Herman Schussler, one of the minority of engineers who recognizes the sanitary and economical value of the Waring system. Here there are twelve thousand inhabitants, occupying eighteen hundred houses on an area of 2,200 acres. All the houses are connected with the sewers. The rainfall is dealt with in well-paved gutters on each side of the roadways. It gives no inconvenience and finds its way to the bay. There are forty-one miles of sewers, the largest being fourteen inches in diameter. There are 130 flushing tanks of the form exhibited.* Their action is automatic. Fifty gallons of clean water is dumped into the head of each lateral sewer four times a day. It fills the whole area of the sewer for a considerable distance. On the lowest grades, one in 250, it travels about three feet per second, and clears out everything which has been deposited during the previous six hours. No sewer runs more than half full except when flushed. The outfall sewers are three in number: they are filled at high tide with salt water and are clear at low tide. I consider them the least satisfactory part of the system. There are no deposits, no bad odors, and stoppages are unknown. Should there be the least evidence of smell the flush tanks are set to empty themselves more frequently. In some laterals there is no need for flushing every day. The sewers are very freely ventilated at the tanks, man-holes and houses.

The entire management, regulation and repairs occupy two-thirds of the time of two men. The water used in flushing costs thirty cents per thousand gallons, or about $8.00 per day. The Alamedans boast that they are as healthy a community as any in the world of a like size. Last year there were 144 deaths, giving a death rate of only twelve per thousand. Forty-five of these deaths were of immigrants, invalids attracted by the climate, coming of less than one year's residence. There were nine deaths from diptheria, but in no instance was it caused by local insanitary conditions; none of the children were attending school. The medical officer is satisfied that these deaths arose from intercourse with Oakland and San Francisco. The total cost of the Alameda sewers, including flushing tanks, man-holes and outfall sewers, was $290,000. The outfalls alone cost $60,000, and all the rest cost about one dollar per foot. After repeated inspections I am of opinion that Alameda is sewered better and more safely than any city in the world. Let me beg every one who is interested in this question—and who is not?—to inspect it for themselves. Mr. E. B. Mastick, the well-known lawyer, is the moving spirit of this admirable work. He is the inventor and patentee of the very simple flushing tank you see before you. This is placed on the border of the sidewalks, in a brick cistern covered with an iron lid. The total cost in place is $50. This is a flusher of smaller dimensions made for domestic use. The tank is fed from the bath tubs, wash basins, laundry and kitchen, and the flush is delivered into the highest initial point of the house drain. Everything in front is effectually carried out to the street sewer. All large houses should have one of these.

* Vide Appendix.

Now once more to revert to San Francisco that I may contrast the very latest work of our sewerage authorities with that of Alameda.

The Richmond District is situated north of the park, being bounded by Twelfth and Thirty-second Avenues east and west and by D street on the south and Lake street on the north. The area is about 500 acres. The district is entirely independent of the San Francisco sewers. The surface is elevated from 150 to 250 feet above the level of the Pacific Ocean, to which an outlet will be made. There are no natural watercourses. The ground consists of a deep drifted sand, by which the rainfall is absorbed with great rapidity, making underground quicksands and watercourses which drain into Mountain Lake. It is evident that there can be no need for special arrangements to take away the rainfall. Judging from the assessment frontage, there are about twenty miles of streets.

At the petition of the property owners the streets were graded and an assessment district formed for the purpose of building sewers. I suppose these plans were made without either the knowledge or consent of the petitioners. Contracts were, however, entered into about two years ago, and about three and a half miles of sewers have been constructed; 2.62 miles are of brick, mostly three by five, and eight tenths of a mile of it is pipe sewer of considerable size. There is no flushing apparatus; indeed, flushing destroys brick sewers of this size with great rapidity. Besides there is no natural supply of water. The sewers, although completed, have not as yet received a drop of sewage; many are hermetically sealed to keep out sand; they await the construction of the outfall. This three and a half miles of sewers has cost $142,000, or about $40,000 a mile. The plans for the outfall are complete; they will be constructed on the usual gigantic scale, and the largest will be six feet five inches in width and five feet nine inches high, with an invert somewhat similar to that of Army street.

The construction of this huge conduit is, of course, designed for the conveyance of prospective rainfall, because all the possible household sewage of the district would be easily and safely delivered by a twelve-inch pipe. The ground being full of quicksands, the sewer will have to be timbered and concreted underneath in many places; part also, is tunneled, and the probable cost for 3,300 feet will be over $60,000. But when this is finished there will be more to do. Only five out of twenty miles of streets will be provided with sewers. Observe also that it will be quite impossible to keep out sand. Clouds of it rise with every breeze; it will collect at the corners, and the first rainstorm will fill up the cesspools as it does everywhere in the Western Addition. The evils of Channel street will be repeated. In summer time there can be no flow of sewage; until the district is settled up with houses and inhabitants, no sewage will ever reach the outlet, but will fester underneath the streets.

In such a district, provision for the rainfall could have been easily and cheaply made by gutters on the streets. Everywhere else it sinks into the porous, sandy soil, and it is just for such conditions that the separate system is best adapted. Now it is

impossible to believe that the property owners exercised the least control over this work, or that the true situation was explained to them. When private individuals start in upon works of this nature, they usually seek the latest information. They look first for efficiency and then for true economy.

Let me offer an example close at hand. The South San Francisco Land & Improvement Company have recently located a townsite at South San Francisco. Its area is 172 acres, and provision will be made for 30,000 inhabitants. The town will have six miles of streets. Every street will be sewered, and the laterals will be carried to the margin of every lot. The rainfall will be dealt with on the surface, being carried away by gutters on the sides of the roadways. The gentlemen interested have no one to consult. They have had no occasion to petition for the services of the city engineer. They have had personal experience of the Waring system at Omaha, where three-quarters of a mile square is sewered on the separate plan, and this notwithstanding the frightful rainstorms which occur there. They are thoroughly convinced that the Waring system is the best, and they expect to profit by their Omaha experience and to make it perfect. The six miles of sewers will be constructed under close supervision by day labor. The materials will be the best obtainable. The pipes are vastly superior to those in use in San Francisco. They will be joined by the Stanhope plan. Every sewer will be made water tight and tested before covered up. The largest sewer for these 30,000 people will have a diameter of ten inches, and there will be only 500 feet of it. There will be 7,000 feet of eight-inch sewer, 5,300 feet of six-inch sewer and over 10,000 feet of four-inch. There will be Mastick flushers at the head of every sewer; manholes on the Alameda plan at the proper points. The gradients are moderate and increase toward the outlets. When completed, South San Francisco will be more perfectly and more safely sewered than any other place with which I am acquainted. The water for flushing is obtained from two artesian wells which yield 1,200,000 gallons daily, or an average of forty gallons per head per day of the population. This is twenty-five per cent higher than the supply of London and the manufacturing cities of England. But its quantity may easily be increased. The sewers, small as they are, will

take it easily away, and will not run more than half full except when flushed.

Now the cost of this admirable system, *complete at all points*, will be under fifty cents a foot, say $2,700 a mile. Instead of paying two hundred thousand dollars for five miles, the proprietors of South San Francisco will construct six miles for less than sixteen thousand dollars and get flushers free. If the Richmond people had adopted the separate plan they would have saved $184,000.

Even now I believe it would be better to save the sixty thousand dollars which the outfall will surely cost, and commence *de novo* on the separate plan. For half this sum they may secure ten miles of sewers with manholes, flushers and outfall complete, and with the other thirty thousand they may make roads, gutters, parks and erect a statue to the city engineer.

To sum up the advantages of the separate system of small sewers:

1. They are adapted for constant daily use throughout the whole year, the larger being worse than useless when there is no rainfall.

2. They are constructed to carry quickly to the outlet a definite amount of liquid containing all the organic refuse of associated human life.

3. They can be made water-tight, which is not possible with the brick sewers.

4. The quantity of sewage and the gradients being equal, the velocity is greatest in small sewers, and the sewage travels more quickly and more safely to the outlet.

5. Sewers, whether large or small, are never self-cleansing, but small sewers can be kept clean and free from stoppages by frequent flushing with a reasonable amount of water, while large retain the filth, promote deposits and are impracticable to flush.

6. Small sewers are more easily ventilated than large ones.

7. There is less room for the growth of putrefaction and disease-producing germs.

8. If the sewage has to be raised by pumping, the quantity is uniform and is reduced within practical limits. All the sewage is pumped into San Francisco by the Spring Valley Water Company, and can be pumped out more readily.

9. If the sewage has to be taken into deep water far away from the foreshores, the necessary prolongations of the sewers will be small and easily put in place, whilst it will be impossible to carry the Brannan-street sewer far into the bay; and it is offensive where it is.

10. Small sewers are never choked, are less liable to deposits, are more easily cleaned, are more durable, and when injured less costly to repair.

11. They are constructed at one-tenth the cost.

12. They have reduced the death rate in all cities in which they have been used.

In conclusion my hope is that San Francisco will profit by these important and instructive lessons. As the natural watercourses are destroyed, let the existing sewers be used to conduct the rainfall to the bay. There will be no need to prolong their outlets. Rainwater will create no nuisance on the foreshores, nay, rather, it will help to cleanse them. We have seen that these ill-constructed conduits are fit for nothing else. They cannot be purified except by keeping sewage out of them. The entire system of house drainage must be reconstructed on the separate plan, a work which will not be costly and is sure to improve the public health. According to the last municipal report there are 227 miles of sewers. Spring Valley has 280 miles of water-mains, and every main requires a sewer, so that it will be necessary to construct say 300 miles of sewers on the South San Francisco plan. Instead of placing the cost at $2,700 a mile let us make it $5,000, and the whole city will be provided for by a million and a half, or the cost of preventable sickness and death for one year. We shall not have less than two thousand flushers of the Alameda type, all to be operated every six hours or oftener; and it may be asked where shall we get the water, and I propose to get it without the expenditure of a single cent. The Spring Valley people say that the daily winter consumption for the city is eighteen million gallons, or sixty gallons per head. If we put the household consumption at fifteen gallons, which is fifty per cent higher than that of London or the English cities, it is obvious that there must be a domestic waste of fifteen or twenty gallons more. With this enormous waste we cannot expect any reduction in the water rates. To reduce this waste

is a necessity which must arise in the near future. This waste is due to ill-constructed closets and bad fittings. It may be almost entirely stopped. In several English cities the consumption of water has been reduced one-half by waste prevention, and if you will consent to give Spring Valley power to control the fittings and to diminish waste, I venture to affirm that they will gladly give you all the water necessary to flush every sewer in the city four times every day. The arrangement would be one of business. If we had five thousand flushers, they would consume about one million gallons daily, and the Spring Valley would certainly save ten.

Thus we may have sewers, washed clean as a dinner-plate. In them there will be no place for disease-producing germs. The citizens will then have a chance to live a natural term of life and die a natural death.

As a practical outcome of the lecture I would respectfully request the Mayor to summon a public meeting for the purpose of establishing a San Francisco Sanitary Association with the following objects, both imperatively necessary before anything can be done:

1st. To instruct the public in all matters relating to public, domestic and personal hygiene in order that a reconstruction of the sewers shall have popular support.

2d. To promote a reform of the municipal government to the extent of securing a stronger, more permanent and more extended authority, with power to appoint a secretary, engineer, medical officer of health, chief inspector of nuisances, administrator of public institutions, and chemist, who shall be elected and retain their offices during good behavior. The personnel of this authority to be ex officio members of the Board of Supervisors.

APPENDIX A.

THE MASTICK FLUSHER.

The tank is simple, and when filled turns over and empties automatically. No parts require oil, and there are no wearing surfaces. When empty the tank recovers its original position. It is fed by a small stream from the water mains, and it may be set to turn over every two, four, six or twelve hours as required. It is only necessary to see that the water tap runs properly. The tank is placed under the sidewalk, and is covered by an iron lid. The cost complete in place is under $50.

Mr. Mastick will present to the city the right to use this patent without the payment of royalties, on the sole condition that he be satisfied that the Flushers shall be made and put in place to his satisfaction.

The printing and distribution of this lecture is due to the public spirit and generosity of Mrs. Phœbe Hearst, to whom and the late Senator the author owes a large debt of respect, gratitude and friendship extending over many years.

CHANNEL-STREET SEWER.

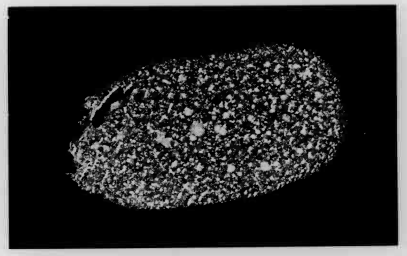


PLATE 1.

Germs cultivated from one drop of channel-street sewage taken at the outlet of the sewer. One drop has been mixed with sterilized gelatine, and after a few hours every germ present grows into a colony of millions. There are upwards of fifty thousand colonies on this plate.

WASHINGTON AND DRUMM STREETS—HIGH TIDE.

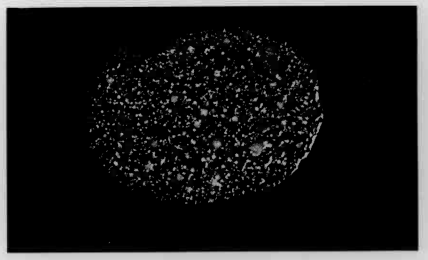


PLATE 2.

This sewer is never empty. At high tide it is filled to within two feet two inches of the surface of the street, and the sewage is diluted with sea water. The number of germs in one drop is estimated at twenty-two thousand.

INTENTIONAL SECOND EXPOSURE

The printing and distribution of this lecture is due to the public spirit and generosity of Mrs. Phœbe Hearst, to whom and the late Senator the author owes a large debt of respect, gratitude and friendship extending over many years.

CHANNEL-STREET SEWER.

PLATE 1.

Germs cultivated from one drop of channel-street sewage taken at the outlet of the sewer. One drop has been mixed with sterilized gelatine, and after a few hours every germ present grows into a colony of millions. There are upwards of fifty thousand colonies on this plate.

WASHINGTON AND DRUMM STREETS—HIGH TIDE.

PLATE 2.

This sewer is never empty. At high tide it is filled to within two feet two inches of the surface of the street, and the sewage is diluted with sea water. The number of germs in one drop is estimated at twenty-two thousand.

WASHINGTON AND DRUMM STREETS—LOW TIDE.

PLATE 3.

At low tide it contains from two to three feet of black mud. The germs from one drop cannot be counted.

EXPOSURE TO SEWER GAS.

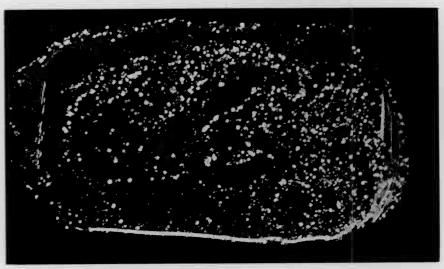
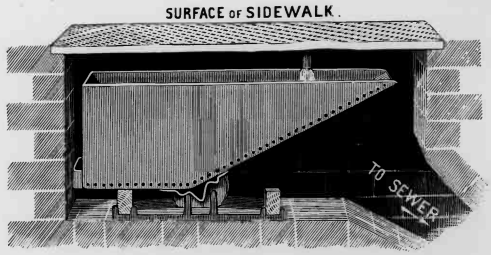


PLATE 4.

A sterilized plate of gelatine was put under a bell glass, over one ounce of the sewage last described. Care was taken to avoid contact with the sewage. In twenty-four hours the plate became infected from the air, and in forty hours this plate exhibits the growth,—a positive evidence of the dangerous nature of sewer emanations.

These cultivations were made by D. H. WAGNER, of 506 Sutter St., S. F.



THE MASTICK FLUSHER.

See Appendix A, page 31.

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INTENTIONAL SECOND EXPOSURE

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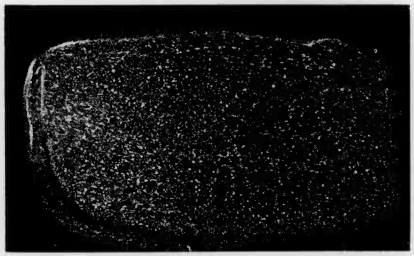

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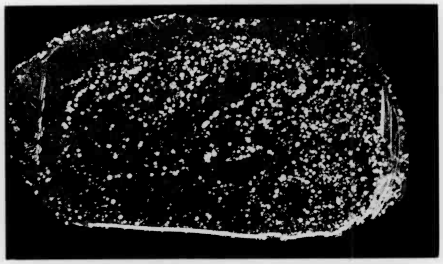

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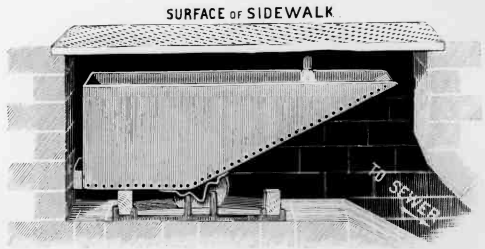

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